Novel ecosystems: governance and conservation in the age of the Anthropocene

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Abstract

Meeting conservation objectives in an era of global environmental change has precipitated debate about where and how to intervene. Ecological and social values of novel ecosystems are particularly contested. Governance has a role to play, but this role is underexplored. Here, we critically review the novel ecosystems literature to identify challenges that fall within the realm of governance. Using a conceptual framework for analysing adaptive governance, we consider how governance could help address five challenges. Specifically, we argue that reforming governance can support the re-framing of policy objectives for ecosystems where transformation is likely, and in doing so, it could highlight the tensions between the emergence of novel ecosystems on the one hand and cultural expectations about how ecosystems should look on the other. We discuss the influence of power, authority and administrative competence on conservation efforts in times of environmental change. We consider how buffering can address translational mismatch between conventional conservation policy and modern ecological reality. This review provides insights into how governance reform could enable more adaptive responses to transformative changes, such as novel ecosystems, while remaining committed to achieving conservation outcomes. Indeed, at their best, adaptive responses would encompass the reality of ecological transformation while being sympathetic to concerns about undesirable outcomes. Connections between researchers in the fields of governance, ecology and conservation could help to achieve these twin aims. We provide examples of governance and policy-making techniques that can support context-specific governance reform that supports more effective conservation in the Anthropocene.

1 Introduction

In what has been dubbed 'the Anthropocene' epoch (Steffen *et al.* 2007), humans are having unprecedented impacts on natural systems. The rapid pace of environmental change has prompted debate about how conservation goals and management should change, particularly for hybrid and novel ecosystems (NE) (Hobbs et al. 2014; Truitt et al. 2015). Hybrid ecosystems occur in highly modified landscapes where key attributes or functions (e.g. nutrient load, hydrology) are the same but most of the species have changed compared with historical ecosystems (Hobbs et al. 2009). The emergence of NE – where species changes are accompanied by altered function and interactions – are likely in many areas across the globe, due to the intensity and pace of drivers of ecosystem decline (Hobbs et al. 2014). At the crux of the debate prompted by NE is the question of whether such changes are reversible and if so, how conservation and restoration policies and practices should be reformed to deal with these transformative changes (Murcia et al. 2014; Perring et al. 2015; Truitt et al. 2015). Accepting irreversible changes and new management objectives challenges a fundamental tenant underpinning ecosystem restoration and biodiversity conservation, i.e. that of anchoring management goals to historical baselines (Hobbs et al. 2014). Consequently there is some palpable anxiety in NE literature, with concerns including displacement of conventional management approaches, whether 'giving in' to NE means 'giving up', and whether the public will accept and value NE (Murcia et al. 2014; Standish et al. 2013).

These concerns raise normative questions about decision-making, responsibility, and social desirability that cannot be answered by collecting more biophysical and

ecological data. These questions are in the realm of governance. Governance provides a link between social and ecological systems, and for better or worse influences the trajectory of these systems (Chaffin et al., 2014). The importance of understanding and reforming governance has been alluded to in this debate; however, so far the NE literature has not engaged extensively with the governance literature. Where it has, the focus has largely been on how governance provides a barrier to sensible management of NE, or on emphasising how social barriers (e.g. community perceptions and cultural expectations) impede progress (Hobbs et al. 2009; Standish et al. 2013; Truitt et al. 2015). The aim of this article is to review the specific aspects of governance that have been discussed in the NE literature, and to identify focal points for governance reform if deliberately pursuing, identifying and managing NE is an accepted conservation option. After a brief discussion of governance in the context of NE, we use a conceptual framework for analysing adaptive governance to evaluate the NE literature. While acknowledging that the pace of governance reform is generally slow to react to the speed or magnitude of many of social and ecological drivers of environmental change, we use insights from this review to develop guidance for a reform agenda that can help build competence for more effectively responding to such transformative changes.

2 Governance and environmental change

Governance is described variously in the literature as both a system and a process. Broadly, governance refers to a system of social coordination for resolving common challenges. More specifically, it refers to the interactions between state and non-

90 state actors undertaken to address these challenges, and includes the institutions
91 and principles mediating those interactions (Armitage et al. 2009; Kooiman, 2003;
92 Lange et al., 2013). Institutions are the rules, strategies and norms that guide
93 individual and organisational behaviour (Ostrom 2005). They can be formal (e.g.
94 laws, constitutions, policies) or informal (e.g. norms, strategies, codes of conduct).
95 Governance occurs at multiple spatial scales and levels (e.g. local, regional, state,
96 national); however, it is distinct from management in that governance sets the vision
97 and direction (e.g. through policy), whereas management operationalises the vision
98 (Folke et al., 2005). Governance is often categorised into different modes, which vary
99 in terms of political processes, policy content, and institutional structures (Lange *et*
100 *al.*, 2013).
101
102 The notion of "fit" is a useful way to link these general ideas about governance to
103 the specific issue of NE. Fit refers to the need for governance to be tailored to the
104 environmental issue being addressed. When governance is fit-for-purpose, it can
105 provide the framework for making difficult decisions discussed in the NE literature
106 (e.g. providing the authority to manage for NE under certain conditions) (Hobbs et
107 al. 2014; Truitt et al. 2015). Examples of poor fit are varied but can include a lack of
108 capacity for dealing with the right drivers, a lack of competence (e.g. skills or
109 resources) for dealing with social or ecological drivers, a failure to manage political
110 influences or insufficient authority to deal with drivers, or an agenda that poorly
111 defines the problem or excludes key players (Clement *et al.* 2016a; Young 2008). This
112 alignment between the problem and governance matters because governance
113 influences how decisions are made about NE, who makes those decisions, who is

114 responsible for acting, and how and why managers intervene. Importantly,
115 governance provides a forum for considering scientific data about transforming
116 ecosystems, but it is much broader than that. It provides a means for considering
117 competing and often conflicting values alongside scientific knowledge to establish
118 overarching objectives. From a practical perspective, it also determines where (and
119 how much) resources are invested in managing ecosystems, and whether that
120 money is invested in more conventional or novel approaches.
121
122 **2.1 Approach to review**
123 We critically reviewed the NE literature to identify "sticking points" or barriers to
124 deciding if, when, where, and how to manage NE for conservation outcomes that
125 authors associated with governance. Papers for the review were obtained from
126 searches for novel ecosystems and related terms (e.g. hybrid ecosystems,
127 constructed ecologies) in search aggregators, which index metadata from a wide
128 scope academic publishers and databases of articles published between 2000 and
129 2016 (e.g. Web of Science, Scopus, JSTOR, Science Direct). We uncovered 118
130 articles, which were then screened for discussion relating to governance aspects of
131 NE, with irrelevant articles being removed from the review, leaving 49 articles.
132 Further screening was then undertaken to remove articles that only briefly
133 mentioned governance and social aspects of NE to arrive at the 15 articles included
134 here.
135
136 To organise the review and provide insight into the areas where governance may
137 need to be reformed to enable more effective action with respect to NE, we applied

138 an original framework developed by Clement et al. (2016a). This framework
139 identifies the aspects of governance that are important for building general and
140 adaptive capacity for conserving biodiversity, as identified in the adaptive
141 governance literature (e.g. Armitage and Plummer 2010; Brunner 2010; Chaffin *et al.*
142 2014) and the broader institutional literature (e.g. Meier and O'Toole 2008; Scott
143 2014). This focus on adaptive governance was chosen because, while traditional
144 governance systems tend to adopt a rigid, rules-based approach to decision-making,
145 adaptive governance offers alternative principles for decision-making better
146 equipped to cope with uncertainty and complexity in ecosystem management
147 through a more experimental, learning-driven approach (Chaffin et al. 2014).
148 Acknowledging that ideals of adaptive governance are difficult to achieve, the
149 framework explicitly considers adaptive capacity alongside practical constraints
150 limiting adaptation (e.g. budgets, legal constraints, accountability mechanisms)
151 (Clement et al. 2016a). The framework attends to adaptive capacity, or the ability of
152 institutions to withstand and respond to change (Armitage and Plummer 2010); but
153 equally highlights the importance of general capacity, or the ability to identify and
154 solve problems and deploy knowledge and skills (Virji *et al.* 2012).
155
156 The framework can be applied to specific cases to determine where governance is
157 and is not fit-for-purpose, but here it is used as an analytical tool to review where
158 the literature has identified poor fit (Section 3), identify areas that have been
159 neglected in the literature (Section 4), and then develop guidance on techniques that
160 can be used to help guide governance reform in particular places.
161

The benefit of a diagnostic approach is that it focuses analysis on the governance aspects most salient for dealing with an environmental problem, in this case aspects of adaptive governance salient to the emergence of NE. The conceptual framework is organised as four broad categories:

1. **Problem and players**, which has two components: how the problem is *framed* including who is causing and could be involved in solving the problem, and the *culture and norms* that drive behaviour.
2. **Politics**, which consists of two components: how institutions interact (*interplay*) and the *power and authority* influencing action.
3. **Competence** includes three components: basic skills and resources for action (*administrative competence*), *cooperation*, and *learning* processes.
4. **Capacity**, which encompasses essential aspects for adaptive capacity in three components: *leadership*, *buffering*, and *self-organising*.

Every component of this framework is built on the notion of fit discussed earlier. The framework is fully described in Clement *et al.* (2016a) and summarised in more detail in the supplementary material. In this case, the focus was on the areas of poor fit identified by authors in the NE literature, with the framework providing a way to organise ideas in the concerns in the NE literature. All information relating to governance from the articles were organised and categorised, using a priori codes from the framework and a second level of analysis to cluster the data and identify themes (Creswell 2013).

3 Governance challenges for managing novel ecosystems

186 Of the 10 components in the framework, only five components (framing, culture and
187 norms, administrative competence, power and authority, and buffering) emerged as
188 most prevalent in this literature, which are discussed here as “sticking points” (see
189 also supplementary material). These are not the only barriers to dealing with NE and
190 may in fact be perceived, rather than actual, barriers. Regarding perception,
191 attention to these five components of governance, whether through further
192 research or targeted, context-specific governance reform, could advance the debate
193 about NE and enable more effective adaptation in landscapes where drivers of
194 environmental change are intense and restoration to historical baselines has become
195 a challenging, if not impossible, endeavour. After summarising the governance
196 challenges presented in the NE literature, we draw attention to components of the
197 framework that have been neglected in this literature, bringing in insights from the
198 governance literature to discuss how governance reforms and interventions could
199 provide capacity to proactively meet the challenges of NE intervention (Section 4).
200

201 **3.1 Framing**

202 Framing refers to how biodiversity and conservation are conceptualised in a
203 particular place, how environmental problems are defined and consideration of their
204 causes. Framing drives the rationale for conservation, determines who is involved,
205 and what solutions and/or actions are deemed acceptable (Clement et al. 2016a).
206

207 Authors argue that current legal and policy frameworks are a poor fit for
208 accommodating novel ecological challenges and solutions. This misfit includes policy
209 and legal barriers to managing and restoring ecosystems in novel ways (Collier 2015;

210 Hobbs et al. 2009), and failure to consider the value of NE or functional equivalence
211 in current approaches (Starzomski 2013). The lack of clear definition and diverse
212 ways of viewing the problem and potential management actions are also said to
213 impede progress for addressing the challenges of novel and hybrid ecosystems
214 (Morse et al. 2014; Murcia et al. 2014; Truitt et al. 2015).
215
216 Although understandings of "natural" vary across countries, biodiversity
217 conservation is still largely framed as the protection of rare and/or culturally valued
218 assets (e.g. species, habitats) from threats and success is anchored to culturally
219 relevant baselines. These tendencies have been criticised for focusing too much on
220 outputs (e.g. number of trees planted) and neglecting outcomes (e.g. ecosystem
221 processes), leading organisations to do the same and contributing to policy failure
222 (Bennett et al. 2009). The critique is even more relevant as ecosystems transform, as
223 new types of ecosystems will require new ways of framing the problem of
224 biodiversity decline, defining what conservation means, and the portfolio of possible
225 solutions. This re-framing will require a clear and practical definition of NE (Hobbs et
226 al. 2014). Any re-framing must also be balanced against potential unintended
227 consequences and deterioration of standards (Graham et al. 2014; Standish et al.
228 2013).

229 **3.2 Culture and Norms**

230 Culture and norms influence behaviour through shared perceptions of what is
231 proper and improper behaviour in a particular situation (Ostrom 2005), thus having
232 consequences for what is deemed acceptable in conservation and restoration. This

component refers not just to societal norms, but also the culture and norms of scientists, practitioners, and the organisations responsible for conservation (Clement et al. 2016a).

Framing (and re-framing) of conservation is part science and part culture, but it is the cultural aspects that have received much attention in the NE literature. One of the recurring concerns about NE is whether the public will de-value them, or simply value them because they are novel (Standish et al. 2013). In the NE literature, this concern is often expressed as a need to overcome community resistance to the idea of NE and dispel idealism about nature (Graham et al. 2014; Hobbs et al. 2009). This discussion is often couched in terms of cultural values toward nativeness and exoticism and cultural values about historic fidelity and ecological integrity (Manning et al. 2009). Authors also refer to sentimentality about historic ecosystems and static views of ecosystems as particular assemblages in particular places in discussing cultural barriers (Hobbs et al. 2009; Hobbs 2016; Light et al. 2013). This sentimentality is not limited to the public, academics and practitioners are also thought to have enduring preferences for conventional management actions (e.g. protected areas, restoration to baseline, protecting specific species), which can be a barrier to accepting novel or more interventionist management options (Hagerman and Satterfield 2014).

Fostering “new norms” is said to be doubly challenging because of potentially dangerous perverse consequences of accepting change (Graham et al. 2014; Murcia et al. 2014; Standish et al. 2013). There are fears discussed in the NE literature that

changing cultural norms about what is worth protecting will be used in a political context to support degrading actions (Murcia et al. 2014). Ultimately this fear reflects that the emergence of NE and hybrid systems raise value-laden questions about conservation that require broad public dialogue (Hobbs et al. 2014; Hobbs 2016), yet social values in relation to NE are largely unknown (Collier 2015).

3.3 Power and authority

Governance establishes institutions and policies; empowers individuals and organisations to act; and allocates roles, responsibilities, and authority. Authority confers formal power to act and can be codified in law, but it may also be more informal and arise from differing levels of political influence, money, or other resources. The framework used here draws attention the fact that while power can block governance reform and effective action, it can also empower actors and enable collective action (Clement et al. 2016a).

Power and authority are rarely discussed in those explicit terms in the NE literature, but there are concerns that intentional management of NE legitimises human control over the environment, potentially empowering actors to degrade ecosystems under the guise of conservation (Graham et al. 2014; Murcia et al. 2014; Standish et al. 2013). There are also practical legal challenges, with authority tied to formal legal frameworks and land tenure constraining action (Hulvey et al. 2013). New approaches will also require reallocation of rights and responsibilities and setting new procedures for practice (Richardson and Lefroy 2016).

3.4 Administrative competence

Administrative competence refers to the basic skills and resources required to conserve biodiversity, and it is this component of the framework where the pragmatic concerns in the NE literature about cost, technical knowledge, and skills are accommodated. Translating biodiversity conservation from paper to practice requires knowledge, capacity to manage in general as well as to adapt, and human and financial resources commensurate with the scale of the problem (Clement et al. 2016a). Many of the debates in the NE literature relate to balancing resource constraints against what is and is not feasible in practical terms.

The feasibility of managing for historical, hybrid, or NE is determined in part by budget constraints and scale of interventions. Authors call attention to the need for new practices and technical knowledge about how to manage NE and the efficacy of differing management actions (Collier 2015; Hobbs et al. 2014; Seastedt et al. 2008). Criteria including reference points, baselines, and bio- and environmental indicators as metrics of change are needed to standardise the use of the NE concept for management and policy decision-making (Morse et al. 2014; Truitt et al. 2015). This is both a scientific and a normative challenge. While anchoring management objectives to historical baselines may still be theoretically possible in some landscapes; it may require unrealistic resource investment, calling into question not just technical feasibility but also financial viability of projects and whether it is an acceptable use of resources (Hobbs et al. 2014; Hulvey et al. 2013). This prospect raises questions about costs, benefits, and realistic objectives for transforming landscapes. A bigger issue here is the mismatch between changing social and

305 ecological context and current approaches to conservation (Collier 2015; Seastedt et
306 al. 2008).
307
308 **3.5 Buffering**
309 Conservation in the Anthropocene means adapting conservation practices to deal
310 with transforming ecosystems and increasing human pressure on the environment.
311 Buffering is about directing responses to the right drivers and being able to manage
312 both internal and external influences (both social and ecological) on an ecosystem as
313 well as the organisations managing those ecosystems. It is key aspect of social-
314 ecological resilience, requiring managers to recognise thresholds and disturbances,
315 respond adequately, and cope with uncertainty to buffer human influence on
316 ecosystems (Boyd and Folke 2011). Effective buffering is a balancing act:
317 conservation organisations must be open to their environment but some
318 management of political and other external pressures is required to effectively
319 manage ecosystems and respond to drivers of decline (Clement et al. 2016a; Meier
320 and O'Toole 2008).
321
322 Questions about how to adjust strategies in light of the transformative changes seen
323 in novel and hybrid ecosystems are contentious and debated on both scientific and
324 philosophical grounds. For example, concerns have been raised about defining NE,
325 predicting ecological responses to rapid change, the irreversibility of change,
326 whether NE are inevitable and where to manage for them, and whether doing so
327 gives licence to degrading actions (Murcia et al. 2014; Perring et al. 2015; Truitt et al.
328 2015). All of these are buffering questions because they are about knowing how to

329 respond adequately to environmental changes at the right times and doing so in the
330 midst of external pressures and under conditions of significant uncertainty.
331
332 A considerable issue related to all of the above links buffering to framing. When
333 legislative mandate and formal authority is tied to managing for specific listed
334 species and ecosystems, the ability to buffer, i.e. target the larger-scale drivers of
335 ecosystem decline, is constrained. Narrow framing also means many biodiversity
336 assets and ecosystem processes are not protected by legislation but may be valued
337 nonetheless (Hobbs et al. 2009; Seabrook et al. 2011). While there is some
338 discussion in the NE literature about how governance needs to enable different
339 responses according to local contexts and mechanisms to adjudicate between
340 different perspectives (Richardson and Lefroy 2016), this discussion is fairly narrow
341 and only hints at the need to address 'fundamental influences' on conservation and
342 restoration such as social values (Collier 2015).
343
344 **4 What is missing from this literature, and what can be done?**
345 This section uses the framework to identify some of the neglected aspects of
346 adaptive governance not covered in the current literature, and then links the
347 findings of the review to the literature on governance reform to identify techniques
348 that can be used to develop a reform agenda in specific contexts, as well as needs
349 for further research.
350

4.1 Legal and policy reform

Among the five "sticking points" described here, several hinge on a mismatch between conservative frames and shifting reality; whether that be formal framing in policies and law or the cognitive frames of experts and the public. Re-framing what conservation means in the Anthropocene is essential to advancing the debate about NE. This will require reform to both law and policy, which will need to be complemented by re-allocation of effort and resources, although this will need to be done cautiously to avoid "opening the door to impunity" (Murcia et al. 2014). Some recommendations for accommodating NE in formal policies have been provided in the literature (e.g., Bridgewater and Yung 2013), but application in different landscape and cultural contexts remains an open question. Most countries, even those in Europe where concepts of nature are more human-centric compared with elsewhere, will need to amend legislation and policies to accommodate new ecological realities and reconcile them with social preferences for and institutional commitments to conservation.

Without re-framing, conservation will still largely focus on historical baselines (whether cultural or ecological), which neglects the reality of changing ecosystems and related values in legislation, management, and investment. In highly modified agricultural landscapes, for example, there may be few living examples of historical ecosystems, and failing to broaden notions of what is worth protecting neglects key drivers and ecosystems processes, leading to overall biodiversity losses at the landscape scale. There is a link here, too, to administrative competence, as investment is presently geared toward conventional approaches (e.g. protecting

375 species in concentrated pockets of landscapes). Yet changing environmental
376 conditions in some landscapes require experimentation with more interventionist
377 conservation policies and may benefit from more focus on restoration of function
378 across broader spatial scales (Clement et al. 2017).
379
380 Reform could mean adopting objectives that focus on maintaining ecological
381 functions or pursuing strategies that foster adaptation, either in association with or
382 at odds with cultural preferences (e.g. reforesting moorland in the UK). Governing in
383 the Anthropocene requires strategy beyond preserving specific assets and
384 characteristics, and a focus on adaptive capacity and delivering ecosystem services
385 (Bridgewater and Yung 2013). This approach could go some way to addressing
386 confusion between means and ends (Wallace 2003), moving away from the focus on
387 species composition and protecting rare assets, and can be a critical part of re-
388 calibrating conservation objectives (e.g., climate-ready objectives Dunlop et al.
389 2013). Adopting the principles of reflexive law also offers a way to balance the
390 necessity of certainty in decision making with the reality of complex ecosystem
391 dynamics (Garmestani and Benson 2013). In reflexive law, thresholds and adaptive
392 management principles can be built into the structures of formal institutions along
393 with review mechanisms to ensure these are regularly reflected upon and revised to
394 reflect new knowledge. Another way in which law could enable more flexible
395 conservation interventions is to move toward more general principles (rather than
396 specific rules) based legislation, which might focus on conserving ecological
397 processes rather than particular species. This pathway would require careful

implementation, however, as greater flexibility has the potential to enable innovation but comes with the trade-off of less operational and legal certainty.

These formal approaches require explicit consideration of authority and power, which can help guard against unintended consequences potentially arising from acceptance of NE. Carefully considering framing (and re-framing) also enables pursuit of multiple solutions, including more conventional management practices and management frameworks that accommodate NE. Not only could this address concern that the latter will displace the former (Standish et al. 2013), but it also supports variety, important for resilience and building adaptive capacity of institutions (Gupta et al. 2010), especially buffering.

4.2 Connecting the formal to the informal

Reform cannot be limited to formal laws and policies if progress is to be made, however, as informal institutions are known to have equally strong influence on practice (Ostrom 2005). The extent to which informal pathways can support effective governance reform varies across contexts and is influenced by political factors shaping how formal policies are interpreted. In the USA, for example, conservation has been interpreted more broadly or narrowly by administrations over the years in practice, even with minimal changes to the legal framework (Cole and Yung 2010). Although the lack of consistency is challenging over the long term, it can also provide an opportunity to integrate innovative solutions, including proactive responses to transformation, into policy portfolios with minimal legal reform. In other places, e.g. Australia, this may be more problematic where framing relates

422 specifically to the management of listed Matters of National Environmental
423 Significance, but there are signs that the reality of ecosystem transformation is
424 creating a strong impetus to modernise conservation governance (e.g. Clement et
425 al., 2017; Hughes et al 2017; Wyborn et al. 2016).

426

427 Intentional effort to support buffering is another area of focus for governance
428 reform. This effort includes strategies for including a wider variety of interventions
429 into conservation practice, accommodating a broader range of conservation
430 objectives, engaging multiple institutions (redundancy), and a focus on forecasting
431 and responding to changes in the external environment (e.g. population growth,
432 market forces, political pressure) (Boyd and Folke 2011; Clement et al 2016a;
433 Elmqvist et al. 2003). Such strategies need not require dramatic changes to formal
434 institutions, but can help conservation organisations more effectively achieve their
435 objectives over the long term. The prospect of better buffering is, however, limited
436 by knowledge, as current practice is necessarily based on disparate correlational
437 data and there are significant challenges in predicting the specific ways in which
438 ecosystems will change into the future (Purves et al. 2016). Such knowledge
439 limitations compound uncertainty and complexity when considering how to respond
440 to NE.

441

442 Policy and legal reform also cannot, in itself, address the vexed problem of how to
443 reconcile diverse opinions about what biodiversity or landscapes are worth
444 protecting. The NE literature often assumes culture is a barrier to change; however,

this is certainly not always the case, and there can be good cognitive fit between the way the problem is understood by key actors and the ecological reality in a particular landscape (Clement et al. 2017). There is also a constant interaction between governance and cultural norms, which helps facilitate informed discussion and may ultimately result in reconciliation. Biodiversity as a term and mainstream policy objective is but a few decades old, but its enshrinement in formal legal frameworks has contributed to its increasing cultural relevance. Governance provides a forum for bringing scientific knowledge to the community and in bringing stakeholder views into decision-making about how to adapt and respond to the emergence of NE. Ultimately, a more informed and nuanced understanding of how the public and individuals and organisations involved in conservation actually view NE and ecosystem transformation, rather than making assumptions about resistance (e.g. Hagerman and Satterfield 2014), is needed to support new policy objectives and management approaches. Additional research should be done to investigate this question across different cultural, legal, and ecological contexts.

4.3 Areas for further investigation

Our review also points to underexplored aspects in NE literature that could provide more guidance on what can be done. Focusing on interplay, for example, can reveal opportunities for governance reform by revealing conflicting and complementary demands and objectives. Interplay refers to the interactions between institutions and levels of governance (Young 2008). Interplay dynamics can have neutral, disruptive, or supportive effects on addressing environmental problems (Stokke 2011), and can be grouped into three types - functional, political, and regime

469 (Clement et al 2016a). Functional interplay occurs when solving one problem affects
470 another. With respect to NE, this could mean, for example, managing for an NE in
471 one area causes pest problems in another area nearby. Political interplay can also
472 occur because of competing or conflicting goals (e.g. economic development versus
473 habitat protection) and such discordant approaches can vary at different levels of
474 governance. Negative regime interplay could occur if efforts to formalise
475 management of NE conflicts with other institutional regimes (e.g. property rights,
476 economic structures, agriculture) (Vatn and Vedeld 2012; Young 2008). Conservation
477 is often low on the political agenda and can conflict with more prominent goals (e.g.
478 agricultural production), and conservation agencies often have complex, conflicting
479 mandates that are difficult to reconcile (Cole and Yung 2010) or vary across
480 jurisdictions (Clement et al. 2016a). At the same time, interplay can often reveal
481 opportunities for cooperation and areas where conservation and development are
482 complementary, and productive interplay dynamics are often central to achieving
483 reforms in multi-level and networked governance regimes (Clement et al. 2015;
484 Clement et al. 2017).
485
486 Governance reform has a particularly significant role to play in managing interplay
487 dynamics. The range of issues relating to interplay with respect to NE is potentially
488 wide and will vary across contexts, but in most situations governance actors will
489 need to consider how managing NE conflicts or is complementary to achieving other
490 objectives. For example, an NE might include alien species, but intentional
491 governance reform can consider trade-offs and ensure formalised management of
492 NE has positive net effects on biodiversity, climate resilience, and ecological

493 connectivity (Kueffer and Kaiser-Bunbury 2014). Conflicts arising from regime
494 interplay might be resolved in part by intentional efforts by organisations to leverage
495 political discourse to simultaneously achieve political goals and positive outcomes
496 for ecosystems (i.e. institutional ambidexterity; Greenwood et al. 2011; Clement et
497 al. 2016b). In reforming governance win-win scenarios might mean, for example,
498 acknowledging that agricultural intensification is a primary goal in some landscapes,
499 and adjusting the conservation focus to include management of NE. The net effect
500 on biodiversity and key ecological attributes and processes (e.g., connectivity,
501 resilience) would likely be positive as compared with trying to manage historical
502 remnants, an assertion that could be tested in pilot projects prior to widespread
503 implementation. Testing could be part of a broader strategy to leverage diversity
504 that already exists into intelligently designed experiments in different jurisdictions or
505 for different legislative mandates, where comprehensive reform is not feasible. In
506 this way, testing could foster learning as well as enhancing capacity to buffer
507 (Clement et al. 2016a; Cole and Yung 2010). There are many strategies for managing
508 interplay dynamics that can build knowledge, new norms, and capacity for
509 responding to environmental change (Oberthür and Stokke 2011). The specific ways
510 in which interplay could be managed to improve fit will necessarily be context-
511 specific, but it will in most cases be a central part of a governance reform agenda.
512
513 Adaptive capacity and greater flexibility implies a level of self-organising, another
514 neglected area in the current NE literature. Self-organising refers to informal spaces
515 where individuals and organisations share knowledge and experience, and make
516 decisions as a network. Often contrasted with the top-down approach to decision-

517 making, such networks can build capacity for dealing with unknowns, store
518 institutional memory and fill gaps in formal responsibilities (Boyd and Folke 2011). In
519 dealing with novel ecosystems, as with biodiversity conservation in general, it will be
520 necessary to establish central standards and policies to enable new decisions (e.g.
521 choosing *not* to restore a system to its historical state). At the same time, there will
522 need to be sufficient authority at the local level to pursue the most context-
523 appropriate solution based on socio-economic and ecological conditions. These self-
524 organising efforts are happening all over the world (Lorimer 2015), and make use of
525 the principle of subsidiarity (i.e. devolved to the lowest governance level with the
526 capacity to act). While an important source of knowledge about how to deal with
527 novelty in conservation, such initiatives often diminish if they lack institutional
528 support (Clement et al. 2017). Organisations with formal authority for conservation
529 are well placed to support such efforts by providing knowledge and (where possible)
530 resources. Ultimately, governance can ensure novel conservation projects still
531 deliver valuable public goods by establishing key outcomes such efforts should
532 achieve, even if they arrive there via a very different management pathway.
533

534 **4.4 Guidance for approaching reform**

535 While not a panacea for advancing the NE debate, there are a number of ways that
536 governance reform can provide opportunities for bringing actors together to discuss
537 values and scientific information, in order to establish new objectives for
538 conservation fit for the Anthropocene. We have developed general guidance for how
539 to approach governance and policy reform in a way that could advance the debate
540 about how to manage change in transforming landscapes. Ultimately, reform must

541 be context specific and will need to occur at multiple scales (e.g. national, regional,

542 and local). An outline of the key activities and techniques at the national and

543 regional scale are provided in Table 1.

544

545 **Table 1. Integrating novel ecosystems into biodiversity governance**

Decision-making tier	Focus	Types of issues to be considered	Example governance & policy-making techniques
Policy and Vision **National & Supra-Regional (e.g. State, Provincial)**	• Re-defining national-level vision and objectives for biodiversity conservation in the Anthropocene. • Identifying all policy options that could help achieve that vision, including both conventional and novel approaches	• Extent of change in this area, what is driving change, and whether there is competence and capacity for dealing with these drivers. • Analysing whether policy is fit-for-purpose: current policy instruments used, their flexibility to be applied to NE, and their effectiveness in addressing key drivers of change. • Review of national and state or provincial (where applicable) policy to identify where changes to framing are needed. • Examining how revised biodiversity policy including NE can be supported or undermined by other policy portfolios (e.g. agriculture, housing).	• Workshops • Forecasting and backcasting (modelling combining social, economic and biophysical factors) • Policy analysis methods (e.g. institutional diagnosis, checklists) • Community forums • Surveys (experts and community) • Delphi techniques
Strategy and Planning **Regional (e.g. bioregion, landscape-scale)**	• Developing regional vision and objectives for incorporating NE. • Examining alternatives for managing the predicted level change, including both conventional and novel approaches. • Identifying potential pilot projects.	• Analysing where environmental change is projected to be most significant and where NE may emerge. • Clarifying roles, responsibilities, and authority for managing NE. • Identifying regional priority areas where change is expected to be most significant. • Developing a decision-making framework for deciding where and when to manage for historical, hybrid, or NE, using national-level vision and objectives. • Initiating a regional collaborative planning process that incorporates specific proposals emerging from the above. • Engaging the public to understand their views on these proposals.	• Scenario Planning • Resilience Assessment • Citizens juries • Strategic Environmental Assessment • Conservation Action Planning (CAP) • Multi-criteria analysis • Structured decision-making • Establishing informal networks
Specific projects **Local scale**	• Bringing together higher-level principles,	• Design decisions about how to intervene in a specific place. A decision-making framework for this purpose is provided in Hobbs *et al.*	• Deliberative forums • Focus groups • Cost-benefit analysis

Decision-making tier	Focus	Types of issues to be considered	Example governance & policy-making techniques
	local values, and ecological conditions to determine if NE is a viable and acceptable option in context. • Designing interventions and implementing projects.	(2014). • Stakeholder engagement can be more targeted and focused on specific design questions. • Feedback from local-level experimentation is critical for evaluating the effectiveness of governance reform and whether further reforms are needed.	• Feasibility studies • Ecosystem assessment

546 This guidance does not provide a definitive answer to the sticking points discussed in
547 the literature; but it draws on the content of the review to suggest tools and
548 techniques related to governance, which can guide both research and practice. It
549 also suggests the ways in which focusing on governance can help advance the
550 debate about NE and enable new, fit-for-purpose conservation strategies. There is,
551 of course, a strong need for productive interplay between governance levels. This
552 includes insights on values, principles and priorities, as well as feedback on
553 monitoring ecosystem change and subsequent interventions. Local learning about
554 ecosystem dynamics will be critical for advancing knowledge about thresholds,
555 which is a key concern in the NE literature, and could inform policy learning at higher
556 levels, supported by the governance reforms discussed in Sections 4.1-4.3.
557
558 In developing this guidance, we have followed the structure of Fisher's (2007)
559 guidance for tiered, systematic decision-making, which helps highlight the interplay
560 between governance levels and spatial scales. As governance reform is necessarily
561 context specific, we have focused on identifying examples of approaches to support

562 decision-making and capacity-building for addressing the challenges identified in this
563 paper. We have included methodologies capable of building capacity relevant to
564 governing NE, including the need to learn and test different options, cope with
565 uncertainty, explicitly considering buffering and fostering self-organising; such as
566 forecasting, backcasting, resilience assessment, informal network-building, and
567 scenario planning (c.f. Peterson et al. 2003; Boyd and Folke 2011; Polasky et al.
568 2011). Collaborative planning methodologies (e.g. forums, citizens juries) have been
569 selected for their value in building governance capacity, particularly adaptive
570 capacity (c.f. Gupta *et al.* 2010; Berkes et al. 2003). Structured methods for
571 environmental assessment and planning (e.g. Strategic Environmental Assessment,
572 CAP, multi-criteria analysis) are included because they enable systematic
573 consideration of different options and can be applied to both high-level decisions as
574 well as specific projects and thus able to generate discussion about bigger picture
575 policy and governance (Fischer 2007). Methods for bringing stakeholders together
576 and accessing knowledge and values of experts and the public are included because
577 this review suggests they need to be better understood (Section 4.2).
578
579 Our guidance draws on commonly used techniques that could be re-purposed to
580 generate the discussions needed to inform intentional governance reform that is
581 context specific. As well-accepted techniques, they are also able to provide outputs
582 in a form ready to be fed back into decision-making and help to formalise new roles
583 and responsibilities for dealing with transformation. While it is tempting to call for
584 transformation of governance, such radical change is rare and extremely difficult to
585 engineer (Scott 2014; Young 2008); however, building on existing institutional

586 structures and legacies can still lead to productive reform (Mitchell et al. 2016;
587 Schoon 2013). Changes that are conservative at first may help guard against
588 potential negative consequences discussed in the NE literature, and can also build
589 the foundations for larger-scale changes that might be required in the future (Ansell
590 2011; Clement et al. 2015).
591
592 While reforms at the national level will influence action and drivers at the lower
593 levels, we suggest it is at the regional level where the bulk of decision-making about
594 what to do could occur in many countries. Although assessment and subsequent
595 reform needs to be multi-scalar, the regional scale is where the specific attributes of
596 social-ecological systems determine adaptive capacity and resilience (c.f. Walker *et*
597 *al.* 2004). It is also a common scale for collaborative conservation efforts, and thus
598 where the general vision can be translated to specific proposals for how to deal with
599 ecosystem change (Johnson 2001). As compared with the national level, the regional
600 level is also where stakeholder and community engagement becomes more
601 concrete, as national priorities and local trade-offs (both conflicting and
602 complementary goals for society, economy, and the environment) can be reconciled
603 via detailed exploration (Faith and Walker 2002). Thus, focusing on regional
604 governance could be productive, although this focus will of course need to be
605 informed by principles developed at higher levels of governance. It also must be
606 adapted for local conditions, depending on where the power, responsibility and
607 authority for conservation are located, which could be more locally or at a national
608 level in different contexts.
609

610 There are several well-developed tools that could help advance discussion about
611 how to approach conservation in transforming landscapes at the regional level.
612 Strategic Environmental Assessment, for example, is a process that can be applied to
613 all decision-making tiers to analyse the impact of any changes to policies, plans and
614 programs (Fischer 2007). While not used to its full potential as a strategic approach
615 at present, it could be used to consider the big picture questions about what is
616 driving transformation and considering options for how to respond and where
617 resources should be focused. As a tool that is already embedded in many planning
618 frameworks, it can support formal allocation of roles and responsibilities for dealing
619 with the issues discussed in the NE literature. It can also specify feedback
620 mechanisms not just to monitor, but to guard against potential negative
621 consequences of accepting NE that were discussed in the literature.
622
623 Collaborative planning processes such as scenario planning can provide a way for
624 imagining what novel ecological futures might look like, with the regional and local
625 levels providing a manageable spatial focus. Such processes also provide a means to
626 test how changing various aspects of governance can help steer toward a future with
627 better biodiversity outcomes, as well as social and economic sustainability (Mitchell
628 et al. 2016). Governance reforms might include enabling experimentation with novel
629 and hybrid ecosystems in certain areas, giving responsibilities and authority to
630 different organisations, creating new networks for learning and sharing information,
631 or shifting accountability criteria to focus on achieving new or more flexible
632 outcomes (Clement et al. 2015). Bringing scenario planning together with structured
633 decision-making (SDM) processes is something that has not yet been done but could

634 provide a means to test different governance reform and management options
635 (Lamers et al. 2014). SDM is a formal, staged approach for developing objectives and
636 identifying optimal decisions for achieving them, based on known behaviour of
637 ecosystems (Martin *et al.* 2009). The SDM methodology (Gregory *et al.* 2012) is best
638 used to develop criteria to evaluate specific interventions in transforming
639 landscapes, where consequences and trade-offs for socio-economic and ecological
640 systems can be modelled and the required resources can be estimated. Citizens'
641 juries (Crosby 1995) are a largely unexplored method for dealing with the complex
642 issues around ecosystem transformation. Such juries could bring experts to the
643 public to discuss both the pros and cons of deliberatively pursuing NE as part of a
644 new conservation toolkit. Citizens' juries are particularly useful for focusing on
645 specific governance reforms or management options that could be pursued, guiding
646 a more collaborative approach to making decisions about the challenges discussed in
647 this paper.
648
649 Central to governance is the question of who should be involved and when. Certainly
650 national-level and supra-regional changes require cabinet-level support and should
651 involve government agencies with formal responsibility. Governance explicitly calls
652 attention to engagement beyond government, however, and activities at each level
653 in Table 1 should involve analysis of existing roles and responsibilities beyond
654 government to understand how they need to change for reform and implementation
655 of new interventions to be successful. The engagement of experts (e.g. ecologists,
656 legal scholars) is also critical to understand the technical issues with managing NE
657 and reform of legislation to incorporate principles of reflexive law. Public

involvement at the national level would be necessarily broad and should include provision of information on key issues and options prior to any surveys or consultations. However, at the regional level there is the opportunity to engage the public in more substantive and focused deliberations, as noted earlier.

More explicit response to what is being said in the governance literature can also inform an agenda for reform. There is no single template for governance reform, but allocation of authority and responsibility to new actors and directing resources to novel interventions will likely be necessary in transforming landscapes. Although this review provides guidance on some features of adaptive governance that will need to be considered generally, a more thorough, context-specific assessment can identify the specific features of adaptive governance that could be enhanced or reformed to bolster adaptive capacity (Brunner 2010; Clement *et al.* 2017). Certain forms and models of governance may not be able to help with the technical challenge of creating a clear definition of NE and specifying the various degrees of ecosystem change, but it can enable deliberation on this question in the process of policy reform. These social challenges, combined with the technical challenges highlighted in the NE literature (e.g. identifying thresholds, predicting future ecosystem changes), suggest a more specific type of adaptive governance, adaptive co-management, could provide principles for reform. Adaptive co-management puts networks, diverse forms of knowledge and learning at the heart of governance (Armitage et al. 2009), and could be a more fit-for-purpose governance form than current top-down governance for addressing the sticking points discussed here. The utility of these technical questions, which tend to be wedded still to static views of

682 ecosystems even in the NE literature, will also have to be revisited in light of a more
683 dynamic view of ecosystem management.
684
685 At the same time, there is a great deal of debate within the governance literature
686 about the practicalities of implementing adaptive governance and adaptive co-
687 management in practice, which aspects are most important for adaptation, and
688 which forms of governance and aspects of institutions are “best” for dealing with
689 transformation (e.g. Chaffin et al. 2014; Clement et al. 2015 & 2016a; Gupta et al.
690 2010; Koontz et al. 2015; Wyborn 2016). For example there is research supporting
691 the notion that adaptive governance supports management of multiple ecosystem
692 services and enables responses to ecosystem-wide changes, as well as supporting
693 collaboration across diverse interests, sectors, and institutional arrangements
694 (Schultz et al. 2015). Yet this same research highlights that trust and relationships
695 that are built through adaptive governance is not always robust enough when
696 challenged by internal and external political, environmental, and economic factors,
697 all of which are constant features of conservation in the Anthropocene. There is
698 some suggestion that it is better to think in terms of “knowledge governance” in
699 responding to ecosystem transformation, which draws attention to the fact that
700 there are many different options rather than a single right answer (Wyborn et al.
701 2016). Wyborn *et al.* instead suggest attention is paid to the processes that allow
702 conservation actors to draw on different values, rules, and knowledge and
703 strengthen those processes that support adaptation. This suggestion supports the
704 idea that reform is best focused on specific processes and features of governance,
705 rather than striving for a particular blueprint or governance mode.

5 Conclusion

Further significant ecological changes are likely given the intensity and pace of drivers of environmental change, but the relative pace of policy adaptation is slow and governance transformation difficult to engineer. To a large extent, conservation policy and practice is playing catch up with social and ecological change, and we can expect some resistance from practitioners, academics and the public, to the idea of NE for the foreseeable future while others will have accepted these changes as a new ecological reality that needs to be accommodated (Hobbs 2013). It is an open question as to whether concrete evidence on the irreversibility of ecological thresholds will help the grieving process or moreover, if we have time to await these data. Governance reform is not a cure-all, but it can be a source of adaptive capacity to help society and ecosystems cope with environmental change. Addressing the challenge of how to deal with NE requires an interdisciplinary approach in both research and practice, especially to foster closer connections between ecological research on the technical aspects of ecosystem transformation (e.g. questions about indicators, reference points, how to intervene to achieve particular goals, etc.) and governance research on the most promising leverage points for reform. Such connections are critical for advancing discussions about where, why, and how society should adapt to such transformative changes.

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What is a diagnostic?

The framework is based on the diagnostic approach to analysis. This means it concentrates on whether governance is fit to achieve a purpose– in our case, biodiversity conservation. Fit can be considered in terms of space (are responses at the appropriate scale?), time (are responses happening at the right time and over the short-, medium-, and long-term?), or function (are actions directed at the right drivers?). Like a doctor diagnosing a patient, the diagnostic approach involves asking questions about current conditions in order to prescribe an appropriate course of treatment (Young 2008). The benefit of this approach is that it can be tailored to a specific context, and does not assume any single institutional design is 'best'.

Conceptual Framework Components

The conceptual framework is organized as four broad categories: problem and players, politics, and two practice categories: competence and capacity (Table S1). Every component of this framework is built on the notion of fit; the analyst must consider how current institutions fit (or do not fit) with the ecological characteristics of the problem being managed. More information about each category is provided in Clement *et al.* 2016a.

Table S1. Overview of components in conceptual framework

Component and Summary	**Aspects**
Category: Problem and Players	
Framing: Problem-framing sets the agenda and players and drives subsequent actions. Organizations provide the framework through which information is interpreted.	• Definition of biodiversity and scale problems • Diagnosis of problem causes • Evaluation of causal agents and their effects • Proposed solution
Culture and norms: These drive group and organizational behavior through shared perceptions of what is proper and improper behavior in a particular situation.	• Impact of culture and norms on behavior • Cognitive fit
Category: Politics	
Interplay: A range of interacting institutional arrangements influences biodiversity conservation across scales and levels.	• Functional interplay • Political interplay • Regime interplay

Component and Summary	Aspects
Power and authority: Adaptive governance calls for greater power sharing, and devolving authority to appropriate levels. Institutions codify power relations and can block change, but also empower actors and enable collective action.	• Dynamics of power and influence • Authority • Roles and responsibilities
Category: Competence	
Cooperation: Biodiversity attributes and threats occur across tenures and jurisdictions, requiring cooperation between actors and across scales and governance levels.	• Level of cooperation • Conditions supporting or hindering cooperation
Administrative competence: The translation of biodiversity conservation from paper to practice requires knowledge and capability. A shift to larger scale approaches requires commensurate resources and competencies.	• Human resources • Financial resources • Institutional and organizational practices
Learning: A deliberate process of adjusting goals and approaches in response to experience and information. It can enable change but also sustain practices.	• Feedback • Self-reflection • Systems understanding
Category: Capacity	
Leadership and Entrepreneurship: Leadership can be structural, entrepreneurial and intellectual. It can come from any level of governance and provide important functions, including supporting innovation, providing vision, influencing culture, and supporting learning.	• Leadership types and influence institutional practices • Constraints on leadership capacity
Buffering: Institutions must be able to recognize thresholds and disturbances and respond adequately to buffer ecosystems. Organizations need to buffer against changes in the external environment to achieve objectives over the long term.	• Redundancy • Response diversity • Organizational buffering
Self-organizing: Self-organizing networks can build institutional memory, fill gaps in formal responsibilities, and provide backup capacity.	• Subsidiarity • Networks • Institutional support for self-organizing

This table summarises the governance challenges discussed in the novel ecosystem literature in more detail, which form the basis of the summary in Section 3.

Table S2. Summary of governance challenges in the novel ecosystem literature

Reference	Framing	Culture & Norms	Interplay	Power & Authority	Cooperation	Administrative Competence	Learning	Leadership & Entrepreneurship	Buffering	Self-Organising
Collier (2015)	Policy and planning after-use prescriptions are often to seek to restore and rehabilitate; to strive to return the altered landscape to an earlier analogue	Societal values in relation to novel ecosystems are unknown.				Knowledge & skills, e.g. poor understanding of the social-ecological interface (values, perceptions, ecosystem services, etc.) coupled with this new ecology (species dynamics, functions,etc.).			Buffering between social and ecological systems, e.g. since societal values can influence conservation and restoration policies and practice, it future policy prescriptions will need to explore fundamentals.	
Graham *et al.* (2014)	Re-framing conservation as inclusive of novel ecosystems can be problematic	Provides a new, potentially dangerous norm and can justify inaction		Gives authority to potentially problematic ideas that can be misued, e.g. excuse to cause reef degredation in order to "facilitate" novel ecosystems					Shiting to this approach potentially means more problems in the future because of resignation to "profoundly degraded reef systems"	Self-organising to pursue new approaches is difficult to "scale up" if it does not match dominant institutional context
Hagerman and Satterfield (2014)		•Enduring preferences for conventional actions (such as protected areas) as the most important policy action act as a barrier. •Negative affective responses toward more interventionist proposals (ecologists' aversion to 'taboo' options)								
Hobbs (2016)	Different motivations for restoration that may not necessarily align with original restoration goals (e.g. SER)	•Perceived values if systems in different states requires open discussion •Perceptions - degraded vs different, e.g. •impression that novel = degraded, when it does not necessarily mean that. •Need an open discussion on what it means to be degraded				Restoration necessarily depends on the level of resources & scales - determinants of both type & intensity of intervention				

Reference	Framing	Culture & Norms	Interplay	Power & Authority	Cooperation	Administrative Competence	Learning	Leadership & Entrepreneurship	Buffering	Self-Organising
Hobbs *et al.* (2014)	Requires a move away from partitioning environment into dichotomous categories (eg natural/unnatural, production/conservation, intact/degraded).	Decisions about interventions and broader policies are value-laden and require meaningful public dialogue.			Decisions demand broad public dialogue	Human & financial resources, e.g.: •Knowing where to manage for historical, hybrid, or novel ecosystems •Cost of management •Technical challenges				
Hobbs *et al.* (2009)	Priorities for livelihood rather than historical fidelity Somewhat static view of ecosystems as particular assemblages in particular places shackles conservation efforts to unrealistic expectations and objectives	•Sentimentality about ecosystems of the past •Normative definitions of 'natural', 'historic', and 'altered' •Cultural values toward nativeness and exoticism & cultural values about historic fidelity and ecological integrity				•Cost •Technical feasibility			Commitments to historical ideal in restoration projects, despite changing context (mismatch between framing and reality)	
Hulvey *et al.* (2013)	Current framing aligns with cultural norms	•Public resistance to management actions Social norms	Human welfare needs - conflicting goals	Property systems		•Limited budget •Lack of technical knowledge •Gaps in knowledge about the efficacy of management actions				
Manning *et al.* (2009)	Preservationist ethic drives current policies	•Landscapes are fluid, but those changes can manifest in outcomes society may view as good, bad or both. •Ideas of nativeness, e.g. when are they helpful? •Challenge widely held preservationist ethic in conservation.								
Morse *et al.* (2014)	Governance would need to accommodate these aspects of NE: human agency, thresholds, species composition, self-sustaining.					Lack of clear definition limits capacity to practically manage.				

Reference	Framing	Culture & Norms	Interplay	Power & Authority	Cooperation	Administrative Competence	Learning	Leadership & Entrepreneurship	Buffering	Self-Organising
Murcia *et al.* (2014)	No clear definition	Slippery slope in changing cultural norms (see power & authority)		•The power to degrade: •Sending conflicted messages to governments (e.g. they will stop managing invasive species) •Opening the door to impunity, lowering the bar						
Richardson and Lefroy (2016)	Biological feasibility has governance implications, e.g. Codifying standards, which are not normally couched in terms of biological feasibility.	Sociocultural acceptability of restoration	Institutional tractability (complementary policies and institutions are more efficacious)	Need laws that allocates responsibilities, sets procedures for practice, tailored to the context, and "earnestly implemented".	Aligning governance with scales (across tenures, etc.) -requires coordination.		Governance processes need to support scientific research and allow for its testing		Buffering external and political drivers, e.g. need to provide mechanisms to adjudicate differences and modify principles to take account of local contexts.	
Seastedt *et al.* (2008)	•Need for dynamic framework that can deal with uncertainty, embrace change. •Acknowledging change - transformation has occurred and further transformation is occurring.	Setting aside pre-existing perceptions and old ways of doing things, e.g. •Overwhelming focus on non-native species - native species don't necessarily benefit; •addressing unwanted consequences like fuel loads and high nutrient loading)				Current practices are out of step with new needs (see Leadership & Entrepreneurship)		Require new styles of management (and, by extrapolation, governance) - e.g. proactive rather than reactive approaches	Dealing with lag times of new approaches and focusing on the future rather than just fixing existing & past problems	
Standish *et al.* (2013)	•It re-frames our reason for 'doing' conservation, e.g. •Human hubris and the expansion of our impact on ecosystems by shaping them to our will •Challenges the idea that nature has intrinsic value	•Public values these new ecosystems simply because they are new without regard to function or biodiversity •Public attitudes and values, eg. will people value novel ecosystems if they don't have natural heritage value?		Provides authority to and culturally normalises the idea that novelty is valuable in and of itself and part of technological advance.		Adds complexity to ecosystem management and restoration			Creates new challenges that would need to be buffered, e.g. new approaches could engender flexibility or malaise	

Reference	Framing	Culture & Norms	Interplay	Power & Authority	Cooperation	Administrative Competence	Learning	Leadership & Entrepreneurship	Buffering	Self-Organising
Starzomski (2013)	Currently, we do not integrate the value of novel ecosystems or their functional equivalence value into our approaches.	•Certainty that we will move toward novel ecosystems, but need to change view that they don't have value. •Will need to accept arguments from functional equivalence, i.e. to the extent that we are comfortable with patterns in the landscape (biodiversity) leading to processes that we need/enjoy (biodiversity, ecosystem function and services)								
Truitt *et al* (2015)	Reconciling diverse frames, e.g. obtaining consensus on appropriate management actions with diverse perspectives (e.g. biocentric versus anthropocentric)					•Knowledge, e.g: knowing where to manage for historical, hybrid, or novel ecosystems •Criteria including reference points, baselines, and bio- and environmental indicators as metrics of change are needed to standardise the use of the novel ecosystems concept.	Issues with feedback (see indicators point under administrative competence)		Related issue with indicators - they are needed to know when to respond and to identify which drivers need to be addressed.	